

Surface Acoustic Wave Sensor for Protein Detection

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INTRODUCTION

AUTOANTIBODY microarray technology has emerged as a promising technique for the identification of biomarkers for early diagnosis, prognosis, and treatment of many diseases [1]. The use of labeled fluorescence imaging hinders the integration of this technology into a point-of-care (POC) device. A way to resolve this problem is to develop methods appropriate for POC systems that are capable of detecting chemical interactions of proteins [2]. In this study we have utilized a surface acoustic wave (SAW) sensor to monitor the response to different solutions placed on the active surface. The purpose was to observe changes in amplitude and phase as the test solutions changed from liquid to solid phase, and to see if the amplitude and phase were influenced by variations in the viscosity or concentration.

MATERIALS AND METHODS

SAWs are mechanical waves that propagate just below the surface of piezoelectric solids when excited by an electrical signal at the resonant frequency. The mass and viscosity of substances have been found to affect the amplitude and phase shift of the output signal [2, 3]. In this study, a custom SAW sensor having the Love propagation mode was utilized (Sensor SAS, Mougins, France). Using a signal generator (Agilent 8648A, Agilent Technologies, Santa Clara, CA, USA), the SAW sensor was driven by a sinusoidal signal at the resonant frequency of 122 MHz with a peak-to-peak amplitude of 80 mV.

Sample solutions were placed on the SAW sensor and the amplitude and phase shift of the output signal were analyzed (Agilent Infinium 54833D) while the solution dried. Two types of solutions were tested. The first type had a varied concentration (0.0, 0.25, 2.5, 25 $\mu\text{g}/\mu\text{l}$) of the protein bovine serum albumin (BSA) in phosphate buffered saline (PBS). The second type varied the viscosity based on the percentage of acrylamide (2-10%) in sodium dodecyl sulfate (SDS).

Manuscript received February 12, 2010. This work was supported in part by the grants from the NIH and DOD to B. C-S Liu.

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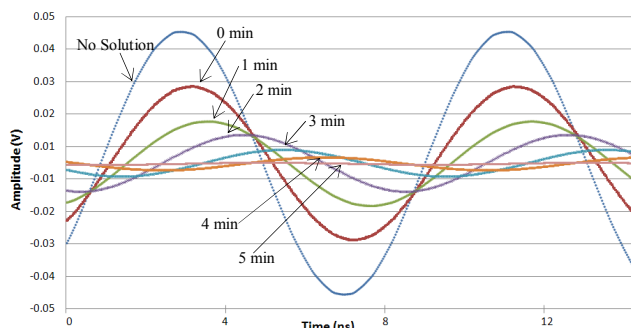


Fig. 1 Output of SAW sensor signal with 2% SDS gel, ranging from no SDS gel on the sensor, SDS gel immediately after placement, and thereafter at 1 minute intervals

The amount of substance placed on the sensor was 2 μl for BSA and PBS testing and 1 μl for SDS gel testing, which typically covered most of the sensor active surface area. Measurement of the output signal was made while the solutions dried (~15 to 20 minutes).

RESULTS

During the first six minutes after the SDS solution was placed on the active surface, the output of the SAW sensor was recorded at one minute time intervals. As time passed and the solution solidified, the amplitude and the phase shift became progressively more attenuated and prolonged, respectively (Fig. 1).

During testing of the BSA concentrations in PBS solution, as the solution dried the amplitude became reduced and the phase shift became prolonged. For solutions with increasing concentrations of BSA, the amplitude progressively attenuated.

These results suggest that the SAW sensor may be utilized for differentiating the state and amount of proteins on the surface. Further testing must be done to verify these results and determine the feasibility of detecting immobilized antibody and antigen interactions.

REFERENCES

- [1] R. J. Caiazza Jr., O. W. Tassinari, J. R. Ehrlich, and B. C-S Liu, "Autoantibody Microarrays for Biomarker Discovery", *Expert Rev. Proteomics*, 4(2):261-272, 2007.
- [2] D. L. Arruda, W. C. Wilson, C. Nguyen, Q. W. Yao, R. J. Caiazza, I. Talpasanu, D. E. Dow, and B. C-S. Liu, "Microelectrical Sensors as Emerging Platforms for Protein Biomarker Detection in Point-of-care Diagnostics", *Expert Rev. Mol Diagn*, 9(7):749-755, 2009.
- [3] D. S. Ballantine, *Acoustic Wave Sensors: Theory, Design, and Physico-Chemical Applications*, Academic Press, CA, USA, 1997.